RepOS project - Preregistration

Study Information

Title A feature-integration theory of attention: the pop-out effect in visual attention experiments.

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Description How we acquire impressions of complex objects is an open question. On the one hand, the Gestalt streaming assumes that sub-components are recognised only after an initial recognition of the corresponding superordinate entity. On the other hand, associationists suggest that a complex impression is inherently built upon a combination of elementary sensations. The feature-integration theory of attention (FIT) is part of the latter one. It postulates that features such as orientation, brightness and colour are processed automatically, fast and in parallel to be arranged in separate spatial representations. Focal attention then acts as glue to bind features of different type to a unitary object based on their spatial overlap.
Visual search is an experimental paradigm in which different entities (usually letters) are presented on a screen. The participant has to report as fast and as accurate as possible if a specific entity called target is displayed (positive trial) or not (negative trial). The target is defined by special features e.g., is of colour. The remaining objects are called distractors and the number of displayed entities is called display size. If no target is displayed The FIT claims that the detection of a target which is defined by only one feature (e.g., colour)requires no focal attention, as it suffices to scan along the corresponding feature representation. This enables the search to take place in parallel over multiple objects. On the contrary, the detection of a target that is defined by multiple features (e.g., colour and shape) requires focal attention to bind the different feature representations. This causes the search to occur serial as focal attention is not able to operate in parallel.
Indeed, visual search experiments (Treisman et. al, 1977) suggest that search time for single target features is independent of display size, whereas search time for conjuncted target features increase linearly with display size. This difference is seen as evidence for the involvement of an additional serial processing step (focal attention) in the latter case.

Hypotheses

1. Visual search in the conjunction condition is serial and self-terminating
   1.1. In the conjunction condition, search time increases linearly with display size.
   1.2. In the conjunction condition, the slope for negative trials is significantly larger than for positive trials.
2. Visual search in the feature condition is parallel.
   2.1. In the feature condition, search time does not increase linearly with display size for positive trials.
   2.2. In the feature condition, search time increases linearly with display size for negative trials.
3. The search in the conjunction and the search in the feature condition only differ when the search field contains more than one item.
   3.1. Search times for trials with display size 1 do not differ between conditions.
4. There is no systematic effect of display size on errors.

Design plan

Study type Browser-based replication experiment

Blinding All relevant manipulations are within-participants. Participants are not informed about these manipulations. The experiment is conducted browser based via the internet.

Study design The experiment is within-subjects design with 3 factors (display size, trial type and condition).

Each participant will be presented four trial blocks, two of the conjunction and two of the feature condition. All trials within one block will exclusively belong to one condition. Each block consists of 32 trials composed of 16 positive and 16 negative trials.

In a block of the conjunction condition there will be 2 trials per trial type and display size configuration.
In a block of the feature block, there will be one trial per target, trial type and display size configuration.

Randomization

All participants see all experimental items. We will randomize the trial order within each block for each participant differently. In addition, we will assign participants randomly to one of the following block orders: FCFC, CFCF (where F is trial block of the feature condition, and C is a trial block of the conjunction condition).

Sampling plan

Existing data

The data from our previous pilot study (N=4) guided the specification of statistical models. This data is not included in the final analysis. No data from the experiment to be registered here was available at the time of preregistration.

Explanation off existing data

Existing data from pilot study does not enter into future analysis.

Data collection procedures

Participants will be drafted through social media, direct email contact and direct text contact. Participation is entirely voluntary but will not be compensated. Every participant is allowed to take part as often as they like.

Sample size

We are aiming to recruit as many participants as possible.

Sample size rationale

Since our pool of reachable participants is limited, we are not in fund of monetary or other incentives to offer, and since time is critical (project deadline) we cannot expect to reach a participant optimum.

Our pilot data (n=4, trials=512) suggests that the linear effects of display size on response time is large (f^2=0.66; computed with partial R^2). A power analysis suggested that significant linear effects of display size on response time can already be found with 30 datapoints (per cell?) (alpha = 0.05, power=0.8).
To be able to reliably determine potential effects across participants we aim for a sample size of 10 participants.

Stopping rule

When the data of at least 10 participants was collected or 14 days have passed since the initial experimental invite we will close data collection.

Variables

Manipulated variables

We manipulate three variables.

1. TRIAL TYPE has two values: positive and negative. It indicates whether a target is present (= positive) or absent (= negative).
2. CONDITION has two values: conjunction and feature. It indicates what kind of target the participants should look out for in the conjunction (green T) and in the feature (S or blue) condition.
3. DISPLAY SIZE takes four values: 1, 5, 15 and 30. It indicates the number of objects shown on the stimuli card. In a positive trial we show one target and an even number of two distractors (brown T and green X). In a negative trial one would see an even

amount of each distractor. For the DISPLAY SIZE 30 we split up the total of 29 distractors in two variants, which will both be shown (compare randomization):

- 15*green X and 14*brown T
- 14*green X and 15*brown T

Measured variables We measure the error rate ERROR, i.e. whether the answer given (target is present vs. target is absent) was correct or not, and the reaction time RT between trial onset and button press. Concretely, variable RT is a metric variable capturing reaction times in ms.; Variable ERROR is a discrete, binary variable registering whether the choice of a trial was correct or not with reference level 'wrong'.

Analysis plan

Statistical models

1. We will use a Bayesian linear regression model to regress *reaction times* based on
2. the interaction effects of CONDITION and TRIAL TYPE and the interaction effects of of DISPLAY SIZE, CONDITION and TRIAL TYPE.
3. We will perform a two-sided two-sample student's t-test comparing the response times in trials with display size 1 between conditions.
4. We will use a standard logistic regression model to regress *error rates* based on the interaction effects of of CONDITION and TRIAL TYPE and the interaction effects of DISPLAY SIZE, CONDITION and TRIAL TYPE.

We will use the statistical analysis program R and the Bayesian regression model brms. We will use the default (flat) priors of the `brms` package for the effect coefficients. The alpha level is 0.05. The attached R script contains the analysis as planned.

Transformations We will not perform any data transformations.

Inference criteria

1.
   1.1. If *both* 95% credible intervals of the posteriors for
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *positive* trials of the conjunction condition and
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *negative* trials of the conjunction condition

   only contain positive values, we will conclude hypothesis 1.1.

   1.2. If the 95% credible interval of the difference between the posteriors of
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *negative* trials of the conjunction condition and
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *positive* trials of the conjunction condition

   only contains positive values, we will conclude hypothesis 1.2.
2.
   2.1. If the 95% credible interval of the posterior for
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *positive* trials of the feature condition

   contains the zero, we will conclude hypothesis 2.1.

   2.2. If the 95% credible interval of the posterior for
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE in *negative* trials of the feature condition

   only contains positive values, we will conclude hypothesis 2.1.
3. If the t-test is significant we will reject hypothesis 3.
4. If *any* estimate of
   - the slope of RESPONSE_TIME as a function of DISPLAY SIZE

   (across the interaction of TRIAL TYPE and CONDITION) significantly differs from zero we will reject hypothesis 4.

Data exclusion We will exclude every trial in which the response time was faster than 200ms or slower than 3000ms. In addition, we will exclude all trials with erroneous responses from analysis 1-3.

Missing data If the participant has finished all 4 blocks, we will include all trials in the analysis. If the participant did not complete the experiment, we will only include the first 2 blocks if these were fully completed.

Exploratory analysis We plan to explore potential differences between trials in the feature condition that utilized targets with a unique shape or a unique colour. We are interested in potential differences in reaction times and error rates.